PART I

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INTRODUCTION

Like its predecessor, the 1996 CAPT science handbook, this *CAPT Second Generation Science Handbook* has been designed to provide Connecticut's middle and high school science teachers with a range of background materials, ideas, tasks and other resources to better align instruction and assessment with the expectations set by the second generation CAPT science assessment.

The underlying philosophy of the science subtest of the CAPT is that science is not only a body of knowledge, but also a way of thinking about the world around us. The philosophy and objectives closely parallel the National Science Education Standards developed in 1996 by the National Research Council, and *Benchmarks for Scientific Literacy*, published by the American Association for the Advancement of Science in 1993.

As you will note, in addition to a summary of the changes in the test and the revised test content specifications, this handbook also contains copies of recently released CAPT performance tasks and a set of sample items that can be used to assess understanding in each of the CAPT science content domains. Teachers may use these materials in a variety of ways:

- Background materials and teaching suggestions can be shared and discussed at department meetings.
- Sample items, including the performance activities, can be used to prepare 9^{th} and 10^{th} graders for the test, as well as to help prepare 11^{th} and 12^{th} graders who choose to retake the test.
- Sample items can be used to help teachers to make instructional decisions and to design instructional experiences that are aligned with the CAPT philosophy of science as inquiry.
- Student work on performance tasks and responses to open-ended questions can be used as catalysts for discussions on curriculum, instruction and achievement.

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THE NATURE OF SCIENCE

> "Over the course of human history, people have developed many interconnected and validated ideas about the physical, biological and social worlds. Those ideas have enabled successive generations to achieve an increasingly comprehensive and reliable understanding of the human species and its environment. The means used to develop these ideas are particular ways of observing, thinking, experimenting and validating. These ways represent a fundamental aspect of the nature of science and reflect how science tends to differ from other modes of knowing." (*Benchmarks for Scientific Literacy,* American Association for the Advancement of Science, Oxford University Press, 1993)

When asking science teachers what is it that they teach, it is not uncommon for the response to be a list of content topics such as *electricity, plants* or *weather.* Most teachers know that science instruction is much more than a presentation of topics; that it includes "the ability to inquire, the capacity to use scientific principles to make decisions and the ability to communicate effectively about science."(*National Science Education Standards,* National Research Council, 1996) The CAPT assesses science literacy by asking students to apply their knowledge of science content and scientific principles.

Curriculum alignment issues, modification of student assessments/tests, instructional strategies and student preparation are discussed in this section of the handbook in order to provide guidelines to science coordinators, district administrators and teachers in their efforts to improve science literacy and student performance on the science subtest of the CAPT.

OVERVIEW OF STUDENT TESTING PROGRAM

For well over a decade Connecticut has been recognized as a national leader in the development of rigorous and reliable tests. Not only do these instruments measure what students know and are able to do in relation to specific educational standards, but also they have clear diagnostic capabilities for teachers and school administrators, and for education in general. Simply put, Connecticut's tests help assess how students are performing academically.

All students are tested annually at Grades 4, 6, 8 and 10. Only certain students with limited English proficiency may be exempt from taking the tests.

The Connecticut Mastery Test (CMT) has been administered each fall since 1985 to students in Grades 4, 6 and 8 in the areas of language arts (reading, writing, listening and mechanics of language) and mathematics. The CMT was updated and improved in 1993 and 2000.

The Connecticut Academic Performance Test (CAPT) is administered in the spring to all Grade 10 students and was given for the first time in 1994. The second generation of the test will be administered for the first time during May 2001. In addition to science and mathematics, the CAPT includes sections on reading and writing across the disciplines.

The CAPT is part of a testing system that provides a logical progression from assessing specific objectives at the lower grades to focusing more on the integration and application of skills at the high school level. These tests provide a challenging and accurate assessment of student achievement statewide. More specifically, the CAPT helps to:

- assess students' academic strengths and weaknesses;
- analyze and modify instructional techniques to address student achievement;
- review curriculum and schoolwide educational strategies to target academic improvements; and
- increase the accountability of the educational system.

The Tests

The CAPT is not at all like the traditional standardized achievement tests. Instead of being tested to see where each student ranks compared to others who took the test, students take criterion-referenced tests designed to measure how well they perform against established standards in a variety of essential and specific skills. Not only do they measure what students know, but Connecticut's tests also measure what students can do with what they know by asking them to respond in writing to questions in order to show or explain their work.

The CAPT includes a science section which consists of a combination of multiple-choice questions and those requiring written responses. Students' understanding of important concepts in life science, physical science, and earth and space science and their ability to apply those concepts in problem-solving situations are assessed. In addition, experimentation skills are assessed by asking students to use scientific reasoning to solve problems. Some of the experimentation questions are related to a laboratory activity that students perform prior to the written test. Specific information about the design of the science test, including the CAPT science framework, sample multiple-choice and constructed-response items, as well as examples of scored student papers, can be found elsewhere in this handbook.

The Results

Results of the CAPT are reported in various ways and are intended to help improve the performance of students, support modifications in curriculum and instructional practices, and stimulate higher expectations for student achievement.

School districts receive sets of student reports, which show how well individual students did on each section of the CAPT. Results are shared with students and parents in October and November.

The CAPT is not a high school graduation test. Students who meet the state goal standards on the CAPT receive a "Certification of Mastery" on their high school transcripts. Students who do not meet the goal state standard in one or more areas have the option of retaking those parts of the test in Grades 11 and 12 in order to gain "Certification of Mastery".

The Standard

The standard for each subtest of the CAPT represents a demanding level of achievement, reasonable to expect of students in the spring of 10th grade.

> ***Students who score at this level possess the knowledge, skills and critical thinking abilities expected of Connecticut's high school students as they prepare for the workforce and/or higher education. These students can apply what they know to complex problems and can effectively communicate their understanding.***

WHY TEACH OPEN-ENDED, PROBLEM-SOLVING ACTIVITIES?

Much of the way science is taught is based on the way it was experienced as students in high school and college classrooms. Science was perceived as being a body of knowledge which was to be transmitted by the teacher to the students. Success was measured by the amount of content covered. Test results and national and international studies, however, show that most of our students do not learn science this way. In fact, they may actually develop a lifelong aversion to it. They see science as an activity having no personal relevance being performed by an elite group with which they cannot identify. Even students who are successful in this model and do not go into science-related careers (the vast majority), come away with a distorted view of what science is and how it actually works.

Changing this situation will require a restructuring of **what** is taught and **how** science is taught. Current national science reform movements promote the concept of science literacy. A scientifically literate person "is aware that science, mathematics and technology are inter-dependent human enterprises with strengths and limitations; understands key concepts and principals of science; is familiar with the natural world and recognizes both diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes." (*Science for All Americans,* American Association for the Advancement of Science, Oxford University Press, 1990)

Science is the product of centuries of human effort to describe, explain, predict and design objects, systems or events in the world around us. Scientific theories and instruments enable us to engage in these activities (description, explanation, predicting and design) with far more power and precision than otherwise would be possible. In teaching science, we must try to help students make sense of scientific concepts and theories and use those concepts and theories to describe, explain, predict and design real-world objects, systems or events.

This is not an easy task. Most students already have ways of describing, explaining, predicting and designing objects, systems and events; ways that lack the power and precision of science, but are based on concepts and theories that make sense to them. Many students also do not think of science as a set of powerful conceptual tools for description, explanation, prediction and design but, rather, as a collection of facts and definitions to be memorized. To learn science with real understanding, these students will have to reorganize their own thinking about how the world works and about the nature of science.

Ideal science teaching is designed to promote conceptual change, help students to see that the way they have understood and explained some aspect of the world is inadequate, even though it seems sensible to them, and help them to understand more sophisticated scientific approaches. This is very difficult to do. Students do not give up familiar ideas or learn new ones easily and, as teachers, we need large amounts of knowledge, skill and planning to help them do so (adapted from documents by C.W. Anderson, E.L. Smith and K. Roth of Michigan State University).

To help students achieve literacy in science, they must be active participants in their own science learning. Quality science classrooms reflect a philosophy that will develop understanding of science content, process and habits of mind.

OPEN-ENDED, PROBLEM-SOLVING ACTIVITIES: A DESCRIPTION

Science is not a matter of belief; rather, it is a matter of conclusive evidence that can be subjected to the tests of observation and objective reasoning. Open-ended, problem-solving tasks ask students to design and carry out their own experiments to solve problems and then write about their results.

A question often asked at workshops about open-ended problem solving is, “How do I include these activities in a curriculum that is already overstuffed?” The answer involves neither pulling activities from a “bag of tricks” nor throwing out the current curriculum. Rather, it involves a redesign of the way science is taught. By rethinking and redesigning present labs and activities, students can begin to understand science content and become independent problem solvers.

Analysis Of An Open-Ended, Problem-Solving Activity

There is no one correct model for designing an open-ended, problem-solving activity. The following five components, however, are found in most successful open-ended activities:

1. **Description of the problem.** The problem description provides a context for investigation and establishes the relevance of the problem for the student.

2. **Assessment of prior knowledge.** Assessing prior knowledge is one of the most important components of any science activity. Students often come to science classes with ways of understanding the world that are very different from the scientifically accepted view (called misconceptions or alternative frameworks). Research has shown that students cannot make sense of science instruction if misconceptions block their understanding. Students and teachers often are unaware that these discrepancies exist. In order for a conceptual change to occur, teachers must become aware of students’ misconceptions and plan activities which are designed to correct them.

3. **Group work.** Most scientists do not work in isolation, they work in groups. It is important, therefore, to structure the classroom so that students work in groups. This should provide a more authentic experience in the K-12 classroom. Students are encouraged to work together to develop an experimental design. The following benefits can be derived from group planning:

    - Students are forced to clarify their conceptions and make them explicit to their peers and especially to themselves. This clarification is necessary because students must understand their personal views before they can recognize the contradiction with new concepts.

    - Students are encouraged to understand the viewpoints of others. This brings into question the validity of their personal views and provides new perspectives that can guide the reshaping of their conceptions.

- Students can internalize and incorporate the processes of modeling, observing and thinking into their personal repertoire.

4. **Individual work.** Individual assignments may serve two purposes: individual accountability and group evaluation. By requiring individual lab write-ups, each student is held accountable for doing his or her own work. It allows each student to incorporate new ideas into his or her own understanding. Teachers who are employing strategies of having students work in groups to learn cooperatively, can use lab reports as the basis for group evaluation, thus encouraging positive interdependence among other members.

5. **Extension activities.** Application activities, or extensions, are an important part of problem-solving lessons because they allow students to practice using what they learned in the activity in new or related contexts.